BERYLLIUM COMPOUNDS

Beryllium compounds are federal hazardous air pollutants and were identified as toxic air contaminants in April 1993 under AB 2728.

CAS Registry Number: 7440-41-7 Be

Molecular Formula: Be

Beryllium is an odorless, hard, brittle, noncorrodible, gray-white metal with a close-packed hexagonal structure. It is highly permeable to x-rays and is resistant to oxidation at ordinary temperatures. Beryllium also has a high heat capacity and thermal conductivity. It is resistant to attack by acid due to the formation of a thin oxide film, but in a powdered or amalgamated form it reacts with hydrochloric, sulfuric, and other acids, and strong bases (Merck, 1989).

Examples of Beryllium Compounds

beryllium acetate	beryllium hydrate	beryllium oxide
beryllium acetylacetonate	beryllium hydride	beryllium oxyacetate
beryllium aluminum alloy	beryllium hydrogen phosphate	beryllium oxyfluoride
beryllium carbide	beryllium hydroxide	beryllium perchlorate
beryllium carbonate	beryllium manganese zinc silicate	beryllium potassium sulfate
beryllium chloride	beryllium metaphosphate	beryllium sulfate
beryllium copper	beryllium nitrate	beryllium zinc silicate
beryllium fluoride		

Physical Properties of Beryllium

Synonyms: beryllium metallic; beryllium 9; glucinium; beryllium dust

Atomic Weight:	9.01
Atomic Number:	4
Valence:	2
Boiling Point:	2500 °C
Melting Point:	1287 °C
Vapor Pressure:	10 mm Hg at 1860 °C
Density/Specific Gravity:	1.85 at 20 °C

(HSDB, 1991; Merck, 1989)

SOURCES AND EMISSIONS

A. Sources

Beryllium is the lightest structural metal known. It can be fabricated by rolling, forging, and machining, but brazing and welding of beryllium are difficult (Sax, 1987). It is used as a component of alloys with copper and aluminum, as a neutron moderator and reflector in nuclear weapons and test reactors, in heat sink material in aircraft brakes, in the manufacture of aerospace guidance systems and mirrors used in space optics, heat shielding for spacecraft, and as an additive in solid rocket fuel (HSDB, 1991). Combustion of coal and fuel oil in grey-iron foundries, coke ovens, utility power plants, and commercial and industrial boilers release beryllium to the ambient air. Other possible sources of beryllium include combustion of fuel, evaporation of heat shields during re-entry of space vehicles and missiles, use of camping lanterns with beryllium coated mantles, and incineration of municipal waste (NTP, 1991).

The primary stationary sources that have reported emissions of beryllium compounds in California are transportation equipment, electrical services, and cement and hydraulic products (ARB, 1997b).

B. Emissions

The total emissions of beryllium compounds from stationary sources in California are estimated to be at least 2,400 pounds per year, based on data reported under the Air Toxics “Hot Spots” Program (AB 2588) (ARB, 1997b).

C. Natural Occurrence

Beryllium is found in the ores of beryl, phenacite, and chrysoberyl. It is concentrated in silicate minerals relative to sulfides and in feldspar minerals relative to ferromagnesium and apparently replaces the silicon ion. The greatest known concentrations of beryllium are found in certain pegmatite bodies. The element is sometimes concentrated in granitic rocks in amounts sufficient to crystallize small amounts of beryl. Precious forms of beryl are emerald and aquamarine. Estimates of beryllium abundance in the earth's crust vary from 2 to 10 parts per million. Certain fossil fuels contain beryllium (Merck, 1989; HSDB, 1991).

AMBIENT CONCENTRATIONS

Beryllium and its species are routinely monitored by the statewide Air Resources Board air toxics network. The network's mean concentration of beryllium (including its species) from January 1993 through December 1993 is estimated to be 0.019 nanograms per cubic meter (ng/m^3) (ARB, 1995c).

The United States Environmental Protection Agency (U.S. EPA) has also compiled ambient concentration data from 47 United States cities during the study year 1978. Information from this study reported an overall range of concentrations of 0.1 to 0.5 ng/m^3 with an overall mean concentration of 0.3 ng/m^3 (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

No information about the indoor sources and concentrations of beryllium compounds was found in the readily-available literature.

ATMOSPHERIC PERSISTENCE

Beryllium compounds are expected to be particle-associated in the atmosphere, and hence subject to wet and dry deposition. The average half-life and lifetime for particles and particle-associated chemicals in the atmosphere is estimated to be about 3.5 to 10 days and 5 to 15 days, respectively (Balkanski et al., 1993; Atkinson, 1995).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, beryllium compounds were the major contributors to the overall cancer risk in 1 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million and contributed to the total cancer risk in 133 of these risk assessments. Beryllium compounds also contributed to the total cancer risk in 41 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million (OEHHA, 1996a).

For the non-cancer health effects, beryllium compounds contributed to the total hazard index in 13 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1 (OEHHA, 1996b).

HEALTH EFFECTS

The probable route of human exposure is inhalation of beryllium dust or fumes (U.S. EPA, 1994a).

Non-Cancer: Acute inhalation of high levels of beryllium can cause inflammation of the lungs in humans; these symptoms may be reversible after exposure ends. Long-term exposure may cause chronic beryllium disease (berylliosis), in which granulomatous lesions develop in the lung. Frequently, these symptoms and detection of the disease are delayed from five to ten years following the last beryllium exposure, but they can develop during the time of exposure. The

symptoms are persistent and frequently are precipitated by an illness, surgery or pregnancy. Chronic beryllium disease usually is of long duration with exacerbations and remissions (Sittig, 1991).

A chronic non-cancer Reference Exposure Level (REL) of 4.8×10^{-3} micrograms per cubic meter ($\mu g/m^3$) is listed for beryllium by the California Air Pollution Control Officers Association Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoint considered for chronic toxicity is the respiratory system (CAPCOA, 1993). The U.S. EPA has calculated an oral Reference Dose (RfD) of 0.005 milligram per kilogram per day for beryllium based on no adverse effects in rats exposed to beryllium in drinking water. The U.S. EPA estimates that consumption of this dose or less over a lifetime would not likely result in the occurrence of chronic non-cancer effects. The U.S. EPA has not established a Reference Concentration (RfC) for beryllium (U.S. EPA, 1994a).

No information on reproductive or developmental effects for humans or animals following inhalation exposure is available (U.S. EPA, 1994a).

Cancer: Inhalation exposure to beryllium compounds has been shown to cause lung cancer in rats and monkeys. The U.S. EPA has placed beryllium in Group B2: Probable human carcinogen. The U.S. EPA has calculated an inhalation unit risk estimate of 2.4×10^{-3} $(\mu g/m^3)^{-1}$. The potential excess cancer risk for a person exposed over a lifetime to 4×10^{-4} $\mu g/m^3$ of beryllium is estimated to be no greater than 1 in 1 million (U.S. EPA, 1994a). The International Agency for Research on Cancer has placed beryllium in Group 1: Human carcinogen (IARC, 1987a). The State of California under Proposition 65 has determined that beryllium and beryllium compounds are carcinogens (CCR, 1996). Three inhalation potency factors have been used as a basis for regulatory action in California:

Compound	Potency value $(\mu g/m^3)^{-1}$	Risk in a million*
beryllium:	2.4×10^{-3}	2,400
beryllium oxide:	2.0×10^{-3}	2,000
beryllium sulfate:	8.6×10^{-1}	86,000

The oral potency factors that have been used as a basis for regulatory action in California for beryllium oxide and beryllium sulfate are 7.0 $(\text{milligram per kilogram per day})^{-1}$ and 3×10^3 $(\text{milligram per kilogram per day})^{-1}$, respectively (OEHHA, 1994).

* The potential excess cancer risk for a person exposed over a lifetime to 1 $\mu g/m^3$ of these compounds is estimated to be no greater than the risk in a million listed above (CAPCOA, 1993; OEHHA, 1994).